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(71) Applicant: JOHNSON SERVICE COMPANY [US/US]; 5757 North Green Bay Avenue, P.O. Box 591, Milwaukee, WI 53209 (US).

(72) Inventors: PASCUCCI, Gregory, Adorno ; W-223 N-2618 Springwood Lane, Waukesha, WI 53186 (US). PIERSON, John, Charles ; 5742 North Milwaukee River Parkway, Glendale, WI 53209 (US). DUENKEL, Gerald, A. ; 1672 Audubon Avenue, Grafton, WI 53024 (US).

(74) Agents: COOPER, John, C., III; Foley & Lardner, 777 East Wisconsin Avenue, Milwaukee, WI 53202 (US) et al.

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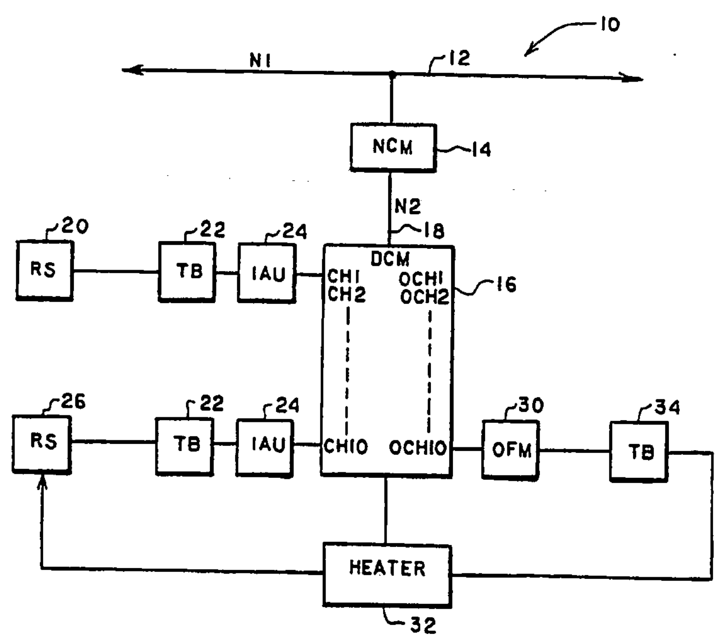

(57) Abstract

A control system input converts any one of different types of analog input information to a given type of analog information which is readable by an input channel (CH10) of a control system. The control system input includes terminal means (22) adapted for connecting a remote sensor (26) to the system and interface means (24) disposed between the terminal means (22) and the control system input channel (CH10). The interface circuit is selectively operable for converting the type of analog information provided thereto by its remote sensor (26) to the given type of analog information to enable its input channel (CH10) to read the analog information provided by the remote sensor.

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UNIVERSAL ANALOG INPUT

BACKGROUND OF THE INVENTION

The present invention generally relates to an input interface circuit and more particularly to a universal analog input circuit which converts various types of analog information to analog information of a given type which can be read by an input channel.

There are many control systems which act upon information obtained at points remote from the control systems. Such information is generally obtained from remote sensors which provide information relative to the condition sensed in analog form.

One such system is a facility management system. Such systems are used to control the internal environment of, for example, an office building or plant facility. Internal room temperature, humidity, air flow lighting and security are among some of the conditions controlled and/or monitored by such systems. These systems provide this kind of control largely in response to information obtained from remote sensors which are connected by multiple wires back to the control systems. Such multiple wires are necessary to both convey the information relative to the condition sensed back to the control system and to enable the control system to provide power to those remote sensors which require external power. Because many different types of conditions are controlled by such systems, many different types of remote sensors are required.

Since many different types of remote sensors are required, and even though the information conveyed to the facility management system normally, in each case, takes the form of analog information, analog information

of many different types may be provided by the remote sensors. For example, a temperature sensor may provide an indication of the temperature sensed in the form of a resistance parameter. Other remote sensors may provide a voltage magnitude indicating the conditions sensed, and still other remote sensors may provide a current magnitude indicative of the conditions sensed.

The control portion of facility management systems usually includes a plurality of input channels for receiving the analog information from the remote sensors. In the prior art, each input channel is hard wired configured to read only one type of analog information. As a result, an input channel may be capable of reading only a resistance parameter, another input channel may be capable of reading only a voltage magnitude, and another channel may be capable of reading only a current magnitude.

Because the number of input channels in such systems is limited, facility management systems of the prior art have lacked flexibility because each input channel of such systems has been capable of being connected to only one type of remote sensor. This lack of flexibility can limit both the overall system configuration and, more importantly, the capability of such a system to adequately control all of the conditions which are necessary to control.

SUMMARY OF THE INVENTION

The invention provides a control system input arranged to respond to a plurality of different types of analog input information received from remote sensors. The system input includes an input channel adapted to read a given type of analog information, terminal means

adapted for connecting a remote sensor to the system, and interface means disposed between the terminal means and the input channel. The interface means are selectively operable for converting the type of analog information provided by the remote sensor to the given type of analog information.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of a control system embodying the present invention.

Figure 2 is a schematic circuit diagram of a universal analog input embodying the present invention and which may be utilized to advantage in the control system of Figure 1.

Figure 3 is a chart identifying the circuit jumper positions and screw terminals used to configure the universal analog input of Figure 2 for various different types of remote sensors which may be connected to the system utilizing the universal analog input.

Figures 4 through 10 are equivalent circuit diagrams of the various input circuit configurations which may be obtained by the selection of the circuit jumper positions and screw terminals identified in Figure 3 for the different types of remote sensors which may be connected to the control system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, it illustrates a control System 10 embodying the present invention and, more particularly, a facility management system embodying the present invention. The system 10 generally includes a main communication bus 12, which may be an N1 LAN

ARCNET bus, a network control module 14, a digital control module 16, and another bus 18, which may be an N2 OPTOMUX bus, interconnecting the network control module 14 to the digital control module 16. LAN ARCNET and OPTOMUX busses 12 and 18 respectively are of a type well knows in the art.

As illustrated in Figure 1, the system thereshown includes just one network control module and digital control module for exemplary purposes only, and it should be understood that additional network control modules with associated digital control modules may be connected to the main communication bus 12 in a practical system. This type of control system is referred to as a distributed system wherein each network control module is on a par with all other network control modules and communicates with all other network control modules on the bus 12.

The main function of the network control module is to communicate with other network control modules of the system on an equal basis and to control its associate digital control module under its own assigned software protocol. Such a protocol may include setting temperature control setpoints, heating schedules, lighting schedules, etc. The network control module, in accordance with its protocol, sends high level commands to the digital control module which then executes on those commands by performing closed-loop operations by issuing suitable control signals at its outputs responsive to sensed input conditions by its remote sensors.

The control signals issued by the digital control module can be both in digital or analog form. A digital control signal can be used to activate relays to in turn activate fan motor starter windings or to turn

on heaters. An analog control signal can be used to power a damper motor to set a damper at a desired position. Hence, the digital control module performs decision making processes, gathers information from its remote sensors, digitizes the information, and executes control functions to satisfy the high level commands of the network control module.

The digital control module 16 thus processes digital information for performing various different types of closed-loop control operations within the system. To that end, the digital control module 16 may include ten output channels identified as OCH1 through OCH10. The outputs OCH1 through OCH10 provide the control signals to control the various different types of control elements of the systems, such as relays or damper motors, to provide the desired control of the internal environment of, for example, an office building. As previously mentioned, relays controlled by the outputs of the digital control module 16 may, for example, turn on or off fan motors to establish desired air flow or heaters to establish desired room temperatures. Damper motors controlled by the digital control module 16 may be utilized to set a damper to also control air flow such as return air flow within a heating system.

In order to provide closed-loop control, the digital control module 16 may include ten input channels designated CH1 through CH10. These input channels receive various different kinds of information from remote sensors within the system, which remote sensors provide analog input information of various types indicative of the conditions being sensed by the remote sensors. Since the information provided by the remote sensors is in the form of analog information, the input channels CH1 through CH10 are arranged to read analog

input information. The analog information readable by each of the input channels is of a given type of analog information, and, in accordance with this preferred embodiment, is a voltage which may be applied across the inputs of a differential amplifier such as, for example, a differential voltage or a single-ended voltage referenced to a fixed potential.

As previously mentioned, various types of remote sensors may be required within a facility management system. Because various types of remote sensors may be required, the analog information provided by the remote sensors may be of various different types of analog information. For example, a temperature sensor may take the form of a temperature dependent resistance so that the temperature sensor provides a resistance having a magnitude which is indicative of the temperature being sensed. Other types of remote sensors may provide analog information of the condition being sensed in the form of voltage magnitudes or current magnitudes carried through a two wire current loop. As a result, the universal analog input of the present invention interfaces the remote sensors with the digital' control module to convert the various different types of analog information provided by the remote sensors to the given type of analog information readable by the input channels CH1 through CH10 of the digital control module. In accordance with this preferred embodiment, the given analog information is a voltage which is applied across the inputs of a differential amplifier. This voltage can be, for example, a differential voltage or a single-ended voltage referenced to system ground or to a digital control module power supply voltage.

To that end, the control system 10 of Figure 1 is illustrated as including a remote sensor 20 which

is coupled to the first input channel (CH1) of the digital control module by an input interface embodying the present invention which includes a terminal block 22 and a universal analog input circuit (IAU) 24. Similarly, another remote sensor 26 is shown coupled to the tenth input channel (CH10) by an identical terminal block 22 and an identical universal analog input circuit 24.

The terminal blocks 22 provide terminal means adapted for connecting the remote sensors to the control system. The universal analog input circuits 24 provide interface means disposed between the terminal blocks and the input channels. The universal analog input circuits, as will be more fully described hereinafter, are selectively operable for converting the type of analog information provided by their associated remote sensors to the given type of analog information readable by their associated input channels.

Since the digital control module includes ten output channels, it may perform up to ten separate closed-loop control operations, each having a unique input and output. One such closed-loop control operation is illustrated in Figure 1 in connection with the tenth output channel (CH10). Output channel OCH10 is coupled to an output functional module 30. The output functional module 30 may be of many different types, and, for purposes of this description, will be assumed to be a relay. The output functional module 30 is coupled to a heater 32 through a terminal block 34. When the relay of the output functional module 30 closes, the heater 32 is turned on for heating an internal space such as a room of a building. The temperature of the room may be sensed by the remote sensor 26 which provides analog information in the form of a resistance having a magnitude indicative

of the temperature being sensed. The resistance analog information provided by the remote sensor 26 is coupled to the tenth input channel (CH10) by the terminal block 22 and the universal analog input circuit 24 as previously mentioned. The temperature information from the remote sensor 26 is converted from a resistance magnitude to the given type of analog information, such as a differential voltage by the input interface formed by the terminal block 22 and the universal analog input circuit 24. When the differential voltage read at the tenth input channel (CH10) indicates that the room being heated by the heater 32 is at the desired temperature indictated by the high level command of the network control module, the digital control module 16, through output channel OCH10, will open the relay of the output functional module 30 to turn off the heater 32. When the room temperature falls below the desired temperature, that condition is sensed by the remote sensor 26, is converted to a differential voltage by the input interface comprising terminal block 22 and the universal analog input circuit 24 to a differential voltage, which then causes the digital control module to close the relay contacts of the output functional module 30 by its output channel OCH10. The foregoing closed-loop process continues until it is interrupted by either an operator manually placing the output function module 30 into a manual mode, or by a command from the network control module 14 to the digital control module 16 through the bus 18. Such a command may be initiated under software control of the system. Such a software command may be desirable, for example, when the heat provided to portions of an office building is to be turned off at night or over weekends.

Referring now to Figure 2, it illustrates a control system input or input interface 40 embodying the present invention. The input interface illustrated in Figure 2 is arranged for interfacing a single remote sensor with a single input channel of the digital control module 16. If all ten input channels of the digital control module are coupled to a remote sensor, each input channel would be associated with an input interface 40 as illustrated in Figure 2.

The input interface 40 generally includes a terminal block 22 and a universal analog input circuit 24. The terminal block 22 includes six screw terminals, screw terminal 1 through screw terminal 6. As illustrated, screw terminals 1, 2, 4, and 5 are available for connection to a remote sensor. Screw terminals 3 and 6 are not utilized and therefore are connected to ground potential. However, where noisy electrical environmental conditions exist, screw terminals 3 and 6 may be utilized for connecting the shields of shielded cables to ground.

Each of the other screw terminals, screw terminals 1, 2, 4, and 5 is coupled to one of the inputs 42, 44, 46, and 48 of the universal analog input circuit 24. More specifically, screw terminal 1 is coupled to input 42, screw terminal 2 is coupled to input 44, screw terminal 4 is coupled to input 46, and screw terminal 5 is coupled to input 48. The four screw terminals enable any of the remote sensors to be utilized within the system to be coupled to the system. Screw terminals 1 and 2 are utilized for receiving the analog information from the remote sensors. Screw terminals 4 and 5 are utilized for providing power to a remote sensor when required. The power at screw terminal 4 is provided by a current limited voltage source 50 within the digital control module 16 which is coupled to the screw terminal

4 through the universal analog input circuit 24. Screw terminal 5 is utilized for the power supply return from screw terminal 4. Screw terminal 5 may also be utilized for connecting a remote sensor to a constant current source. The constant current available at screw terminal 5 is provided by a constant current source 52 within the digital control module 16 which is coupled to the screw terminal 5 through the universal analog input circuit 24 when required.

The universal analog input circuit 24 also includes four outputs, 62, 64, 66, and 68 which are coupled to corresponding inputs 82, 84, 86, and 88 of the digital control module 16. The inputs 82, 84, 86, and 88 of the digital control module comprise one input channel of the digital control module 16.

The digital control module 16, in addition to the current limited voltage source 50 and the constant current source 52, includes a differential amplifier 54. The differential amplifier 54 includes a positive input 56 and a negative input 58. The differential amplifier 54 along with input resistors 51, 53, 55, and 57 enable the reading of the given type of analog information, such as a differential voltage or a single-ended voltage in a conventional manner.

The universal analog input circuit 24 includes internal circuitry which, through two sets of circuit jumpers 70 and 90 provides selectable circuit configurations for converting any one of the various types of analog input information from the remote sensors to a differential voltage readable by the input channel of the digital control module 16. The first set of circuit jumpers 70 includes circuit jumpers S1, S2, and S3. The second set of circuit jumpers 90 includes circuit jumpers S4, S5, S6, and S7. Each circuit jumper

is illustrated as including a pair of terminals. In actual practice, the pair of terminals of each circuit jumper are preferably aligned so that a conductive shorting pin may be inserted into the center of each terminal pair for shorting the terminal pair together and selecting a particular circuit jumper. As can be noted from Figure 2, the terminals of circuit jumper S1 are not coupled to any other portion of the universal analog input circuitry. This circuit jumper is utilized when neither circuit jumper S2 or S3 is required, thus providing a convenient storage place for the shorting pin when it is not actually used.

Except for circuit jumper S1, each of the First terminals of the circuit jumpers is coupled to one of the inputs of the universal analog input circuit 24 through a fuse. More specifically, the first terminal 71 of circuit jumper S2 is coupled to the input 46 of the universal analog input circuit 24 by a fuse 100. The first terminal 73 of circuit jumper S3 is coupled to the input 42 by a fuse 102. The first terminal 91 of jumper S4 is coupled to input 48 through a fuse 104 and the first terminals 93, 95, and 97 of circuit jumpers S5, S6, and S7 respectively are coupled to input 44 through a fuse 106. The fuses 100, 102, 104, and 106 are provided to protect the digital control module circuitry from possible excessive current or voltage conditions which may result due to a defective remote sensor coupled to the terminal block 22.

To complete the description of the circuit jumper connections, the second terminal 72 of circuit jumper S2 is coupled to the first terminal 73 of circuit jumper S3 and to the input 56 of the differential amplifier 54 through the resistor 51. The second terminal 74 of circuit jumper S3 is coupled to a resistor

25 which in turn is coupled to the input 58 of the differential amplifier 54 through a resistor 55. The common node of resistors 25 and 55 are also coupled to the input 44 of the Universal analog input circuit 24 and to the first terminals 93, 95, and 97 of circuit jumpers S5, S6, and S7 respectively. The function of resistor 25 will be described in more detail hereinafter.

With respect to the second set 90 of circuit jumpers, the second terminal 92 of circuit jumper S4 and the second terminal 94 of circuit jumper S5 are coupled to the constant current source 52 within the digital control module 16. The second terminal 96 of circuit jumper S6 is coupled to a negative voltage power supply at terminal 59 which is external to the universal analog input circuit 24. Lastly, the second terminal 98 of circuit jumper S7 is coupled to system ground external to the universal analog input circuit 24 as illustrated.

By virtue of the circuitry just described with respect to the universal analog input circuit 24, different circuit configurations of the universal analog input circuit can be selected by the proper selection of the circuit jumpers and screw terminals on the terminal block 22 to connect any one of the various types of remote sensors which may be utilized in the system to the input channel of the digital control module 16 so that the information provided by the remote sensor can be read by the input channel of the digital control module. Figure 3 identifies the proper circuit jumper and screw terminal selections for seven different types of remote sensors which may be utilized in the system.

Referring now to Figure 3, it can be seen that for a 2-wire resistance temperature device, circuit jumpers S2 and S5 are used along with screw terminals 1 and 2 of the terminal block 22. For a 4-wire resistance

temperature device, circuit jumpers S1 and S4 are selected along with screw terminals 1, 2, 4, and 5. Each of the resistance temperature dependant devices provide analog information in the form of a resistance magnitude. The 4-wire device requires four wires as will be seen herein after to provide a more accurate determination of the resistance than in the case of the 2-wire resistance temperature dependant device. In both cases, the selection of the circuit jumpers and screw terminals identified in Figure 3 configure the terminal block 22 and the universal analog input circuit 24 for converting the resistance magnitudes to a differential voltage to permit the input channel of the digital control module to read the resistance analog information provided by these remote sensors.

As can also be noted in Figure 3, when the remote sensor provides a voltage magnitude of 0 to 10 volts to be read by the input channel of the digital control module, circuit jumpers S1 and S7 are used along with screw terminals 1, 2, and 4. This selection of circuit jumpers and screw terminals configure the terminal block 22 and universal analog input circuit 24 for applying the voltage magnitude as a single-ended voltage across the inputs of the differential amplifier 54.

When a remote sensor comprises a potentiometer from which it is necessary to read the resistance setting of the potentiometer, circuit jumpers S1 and S7 are used along with screw terminals 1, 2, and 4. As will be seen hereinafter with respect to the equivalent circuit of Figure 7, when this combination of circuit jumpers and screw terminals are used, the setting of a potentiometer, which is a resistance, can be converted to a single ended voltage and applied across the inputs of differential

amplifier 54 to thus be read by the input channel of the digital control module 16.

When a remote sensor takes the form of a 3-wire transducer of the type providing an output voltage up to ten volts, circuit jumpers S1 and S6 are used along with screw terminals 1, 2, and 4. With this selection of circuit jumpers and screw terminals, a supply voltage of twenty-five volts is supplied to the transducer by screw terminals 4 and 2. The output voltage of the transducer is made available at screw terminal I with respect to screw terminal 2 to provide a single-ended voltage referenced to the negative supply voltage and is applied across the inputs of differential amplifier 54.

When a remote transducer is configured as a true 2-wire current loop device, which thus provides its analog information in the form of a current magnitude, circuit jumpers $3 and 56 are used along with screw terminals 1 and 4. For this configuration both power and signal are available on the same two wires by supplying twenty-five volts to the transducer through resistor 25. The transducer modulates its output resistance and therefore modulates the current on the current loop. This is read as a voltage drop (differential voltage) across resistor 25.

Lastly, when a remote sensor is self-powered and is configured as a remote current loop, circuit jumpers S3 and S4 are selected along with screw terminals 1 and 2. For both current loop type remote sensors, the circuit jumper selections place resistor 25 across the input 58 and input 56 of the differential amplifier 54 for converting the current magnitude provided by the remote sensors to a differential voltage. For a 2-wire current loop, screw terminal 4 is used to provide power to the remote sensor. Screw terminal 4 is not used for

the remote current loop sensor since this type of sensor is selfpowered.

Referring now to the equivalent circuit diagrams of Figures 4 through 10, Figure 4 illustrates the equivalent circuit diagram of the terminal block 22 and universal analog input circuit 24 when the remote sensor is a 2-wire resistance temperature dependent device. That remote sensor is illustrated as a variable resistance 110. Also, for purposes of simplification, the resistors 51, 53, 55, and 57 along with the specific circuitry of the current limited voltage source 50 have been omitted from the equivalent circuit diagrams.

Referring again to Figure 4, the 2-wire resistance temperature device is illustrated as a variable resistor 110. With the selection of circuit jumpers S2 and S5 along with the screw terminals 1 and 2, it can be seen that one side of the variable resistance is connected to the positive input differential amplifier 54 through screw terminal 1 and the fuse 102. Also with the selection of circuit jumper S2, the resistor 110 is coupled to the positive voltage source 50 of the digital control module. With the selection of circuit jumper S5 and screw terminal 2, the other end of resistor 110 is coupled to the negative input 58 of the differential amplifier 54 through the fuse 106 and to the constant current source 52 through the circuit jumper S5. As a result of the foregoing, a constant current is provided to the resistor 110 so that any change in its resistance will result in a proportionate change in the differential voltage applied across inputs 56 and 58 of the differential amplifier 54.

The circuit configuration of Figure 4 can also be used to sense binary contacts. When such contacts are closed, the resistance will be low and when the contacts

are open, the resistance will be high. The difference in resistance values will provide either a low or high differential voltage across inputs 56 and 58 of differential amplifier 54 for reading the corresponding contact conditions. With this approach, very good noise immunity is obtained due to the differential (balanced) nature of the system.

Referring now to Figure 5, it illustrates the equivalent circuit of the terminal block 22 and the universal analog input circuit 24 when the remote sensor is a 4-wire resistance temperature dependant device and when circuit jumpers S1 and S4 are selected along with screw terminals 1, 2, 4, and 5. This remote sensor is represented as a variable resistor 112. It will be noted that this remote sensor is coupled to the terminal block 22 using four wires. One wire connects the first end of resistor 112 to the current limited voltage source 50 of the digital control module 16 through screw terminal 4 and fuse 100. The first end of the resistor 112 is also coupled to the positive input 56 of differential amplifier 54 through screw terminal 1 and fuse 102. The second end of the resistor 112 is coupled to the negative input 58 of the differential amplifier 54 through screw terminal 2 and fuse 106. Lastly, the second end of resistor 112 is coupled to the constant current source 52 through screw terminal 5, fuse 104, and circuit jumper S4. As will be noted in this configuration, separate wires are utilized to connect the resistor 112 to the voltage source 50 and the constant current source 52. As a result, a constant current is provided to the resistor 112 and any variation in its resistance will result in an accurate variation in the differential voltage applied across the inputs 56 and 58 of the differential amplifier 54. This accuracy is due to the

fact that the current passing through the resistor 112 is converted to a voltage that is not affected by the resistance of the input sense lines including fuses 102 and 106.

Figure 6 illustrates the equivalent circuit when the remote sensor is the type which requires external power and which provides a voltage magnitude of up to ten volts indicative of the condition being sensed. In this case, the selection of screw terminal 4 connects the remote sensor 114 to the current limited voltage source 50 through the screw terminal 4 and fuse 100. The voltage output of the remote sensor 114 is coupled across screw terminals 1 and 2 with the positive side thereof being coupled to screw terminal 1 and the negative side to screw terminal 2. The positive side is coupled to the positive input 56 of the differential amplifier 54 through screw terminal 1 and fuse 102. The negative side of the remote sensor is coupled to the negative input 58 of the differential amplifier 54 through screw terminal 2 and fuse 106. Lastly, with the selection of circuit jumper S7, the negative side of the remote sensor 114 is also coupled to system ground. By connecting the negative side of the remote sensor 14 to system ground through circuit jumper S7, the power circuit to the remote sensor 114 is completed. The negative input of the differential amplifier is not actually connected directly to ground by virtue of the resistor 55 not shown in Figure 6. As a result of the circuit configuration illustrated in Figure 6, the voltage magnitude provided by the remote sensor 14 is applied as a single-ended voltage to the inputs of the differential amplifier 54 to be read by the input channel of the digital control module 16 while power for powering the remote sensor is also provided.

Referring now to Figure 7, it illustrates the equivalent circuit which results when circuit jumpers S1 and S7 are selected along with screw terminals 1, 2, and 4 for connecting a potentiometer to the control system. Here, the potentiometer has been provided with reference character 116.

As will be noted in Figure 7, the first end of the potentiometer is coupled to the current limited voltage source 50 of the digital control module 16 through screw terminal 4 and fuse 100. The opposite end of the potentiometer 116 is coupled to system ground through screw terminal 2, fuse 106, and circuit jumper S7. The opposite end of the potentiometer is also coupled to the negative input 58 of the differential amplifier 54 through screw terminal 2 and fuse 106. Lastly, the wiper 116a of the potentiometer is coupled to the positive input 56 of the differential amplifier 54 through screw terminal 1 and fuse 102. As can be seen from the foregoing, the current limited voltage source provides a voltage across the potentiometer 116 and the voltage between the wiper 116a and ground is read across the inputs of the differential amplifier 54. As a result, the resistance setting of the potentiometer 116 may be determined by the digital control module 16.

Referring now to Figure 8, it illustrates the equivalent circuit when circuit jumpers S1 and S6 are used along with screw terminals 1, 2, and 4 for connecting a 3-wire transducer which provides an output voltage of up to twenty-five volts to the control system. The 3-wire transducer is identified by reference character 118. As illustrated, such transducers require the application of external power. To that end, the transducer 118 is connected to the current limited voltage power supply 50 of the digital control module 16

through screw terminal 4 and fuse 100. The positive side of the voltage output of the transducer is coupled to the positive input 56 of the differential amplifier 54 through screw terminal 1 and fuse 102. The negative side of the transducer is coupled to the negative input 58 of the differential amplifier 54 through screw terminal 2 and fuse 106 and to the external minus power supply through circuit jumper S6. The connection of the negative side of the transducer to the minus power supply 59 through circuit jumper S6 completes the power circuit to the transducer and scales the voltage output to a range readable by the input channel. Again, input 58 of the differential amplifier 54 is not connected directly to the minus power supply by virtue of the resistor 55 not shown in the equivalent circuit of Figure 8. As can be seen, this combination of circuit jumpers and screw terminals enables the 3-wire transducer to be powered and the voltage magnitude output of the transducer to be applied across and read at the differential inputs of the differential amplifier 54. The transducer output voltage is referenced to the system negative supply voltage.

Referring now to Figure 9, it illustrates the equivalent circuit obtained when circuit jumpers S3 and S6 are selected along with screw terminals 1 and 4 for connecting a remote sensor to the control system which provides an output current magnitude indicative of the condition being sensed and which also requires power that is also delivered from screw terminals 1 and 4. The remote sensor 120 is coupled across screw terminals 4 and 1. Screw terminal 4 is coupled to the current limited voltage source 50 of the digital control module 16 through fuse 100. With the selection of circuit jumper S3, the resistor 25 is placed across the differential inputs 56 and 58 of the differential amplifier 54. Also,

screw terminal 1 is coupled to the resistor 25 through the circuit jumper S3. The other side of the resistor 25 is coupled to the negative voltage source 59 through circuit jumper S6. As can be noted from Figure 9, this circuit configuration provides power to the remote sensor 120 by coupling it to the current limited voltage source 50 and directs the current magnitude output of the remote sensor 120 through the resistor 25 which is placed across the inputs of the differential amplifier 54. As a result, the current magnitude provided by the remote sensor 120 is converted to a differential voltage which can be read across the inputs 56 and 58 of the differential amplifier 54 of the digital control module 16.

Lastly, referring to Figure 10, it illustrates the equivalent circuit which is obtained when circuit jumpers S3 and S4 are selected along with screw terminals 1 and 2 for connecting a selfpowered remote sensor to the system which provides a current magnitude indicative of the condition being sensed. The remote sensor is indicated at reference character 122. As will be noted, the remote sensor 122 is coupled across screw terminals 1 and 2 of the terminal block 22. With the selection of circuit jumper S3, the resistor 25 is again placed across the differential inputs 56 and 58 of the differential amplifier 54. Screw terminal 1 is also coupled to resistor 25 through circuit jumper S3 and the fuse 102. With the selection of circuit jumper S4, screw terminal 2 is coupled to the junction of resistor 25 and negative input 58 through the fuse 104. As can be thus noted from the equivalent circuit, the current magnitude provided by the remote sensor 122 is directed through the resistor 25 which is coupled across the inputs 56 and 58 of the differential amplifier 54 by the selection of circuit jumper S3. As a result, the current magnitude provided

by the remote sensor 122 is converted by resistor 25 to a differential voltage which is then read by the differential amplifier 54 of the digital control module 16.

From the foregoing, it can be appreciated that the present invention provides a new and improved control system input for adapting an input channel of a control system to read various different types of analog information even though the input channel is configured for reading a given type of analog information, such as a voltage applied across the inputs of a differential amplifier. This is accomplished by the present invention by converting the analog information provided by each remote sensor to a voltage applied across the inputs of a differential amplifier, whether the remote sensor provides a resistance, a voltage magnitude, or a current magnitude indicative of the condition which it senses. In addition, the interface circuit of the universal analog input circuit may be readily selected by an operator through the selection of circuit jumpers and screw terminals of the terminal block coupled to the universal analog input circuit. As a result, the control system results which has maximum flexibility and which can accommodate many different types of conditions to be controlled.

While a particular embodiment of the invention has been shown and described, modifications may be made, and it is intended in the appended claims to cover all such modifications as may fall within the true spirit and scope of the invention.

What is claimed is:

1. A control system input arranged to respond to a plurality of different types of analog input information received from remote sensors, said control system input comprising:

an input channel (CH10) adapted to read a given type of analog information;

terminal means (22) adapted for connecting a remote sensor (26) to said system; and

interface means (24) disposed between said terminal means (22) and said input channel (CH10), said interface means being selectively operable for converting the type of analog information provided by said remote sensor to said given type of analog information.

2. A control system input as defined in Claim 1 wherein said given type of analog information is a voltage.

3. A control system input as defined in Claim 2 further including a differential amplifier (54) having a positive input (56) and a negative input (58) for reading said voltage.

4. A control system input as defined in Claim 2 wherein said different types of analog input information include voltage magnitudes, current magnitudes, and resistance values.

5. A control system input as defined in Claim 3 wherein said interface means comprises circuit select means (70, 90) for providing different interface means circuit configurations depending upon the type of analog information provided by said remote sensor.

6. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a resistance (110; 112), wherein said circuit select means (70, 90) are selectively operable for providing a constant current through said resistance to convert said resistance to a differential voltage, and wherein said interface means is arranged to apply said differential voltage to said differential amplifier (54).

7. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a voltage magnitude (114) and wherein said circuit select means (70,90) are selectively operable for applying said voltage magnitude to said differential amplifier.

8. A control system input as defined in Claim 7 wherein said circuit select means (70, 90) are selectively operable for applying power to said remote sensor providing said voltage magnitude.

9. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a current magnitude and wherein said circuit select

means (70, 90) are selectively operable for converting said current magnitude to a differential voltage.

10. A control system input as defined in Claim 9 further including resistance means (125) and wherein said circuit select means (70, 90) are selectively operable for placing said resistance means (125) across said differential amplifier inputs (56, 58) and directing said current magnitude through said resistance means (125) to provide said differential voltage.

AMENDED CLAIMS
[received by the International Bureau on 23 November 1990(23.11.90); original claims 1-10 replaced by new claims 1-10 (3pages)]

1. A control system input arranged to respond to a plurality of different types of analog input information received from remote sensors, said control system input comprising:

    an input channel (CH10) including an analog sensing circuit (16) adapted to read a given type of analog information;

    terminal means (22) adapted for connecting a remote sensor (26) to said system; and

    interface means (40) disposed between said terminal means (22) and said input channel (CH10), said interface means including circuit means (24) selectively configurable for converting the type of analog information provided by said remote sensor to said given type of analog information.

2. A control system input as defined in Claim 1 wherein said given type of analog information is a voltage.

3. A control system input as defined in Claim 2 wherein said analog sensing circuit (16) includes a differential amplifier (54) having a positive input (56) and a negative input (58) for reading said voltage.

4. A control system input as defined in Claim 2 wherein said different types of analog input

information include voltage magnitudes, current magnitudes, and resistance values.

5. A control system input as defined in Claim 3 wherein said circuit means (24) comprises circuit select means (70, 90) for providing different interface means circuit configurations depending upon the type of analog information provided by said remote sensor.

6. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a resistance (110; 112), wherein said circuit select means (70, 90) are selectively operable for providing a constant current through said resistance to convert said resistance to a differential voltage, and wherein said interface means is arranged to apply said differential voltage to said differential amplifier (54).

7. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a voltage magnitude (114) and wherein said circuit select means (70,90) are selectively operable for applying said voltage magnitude to said differential amplifier.

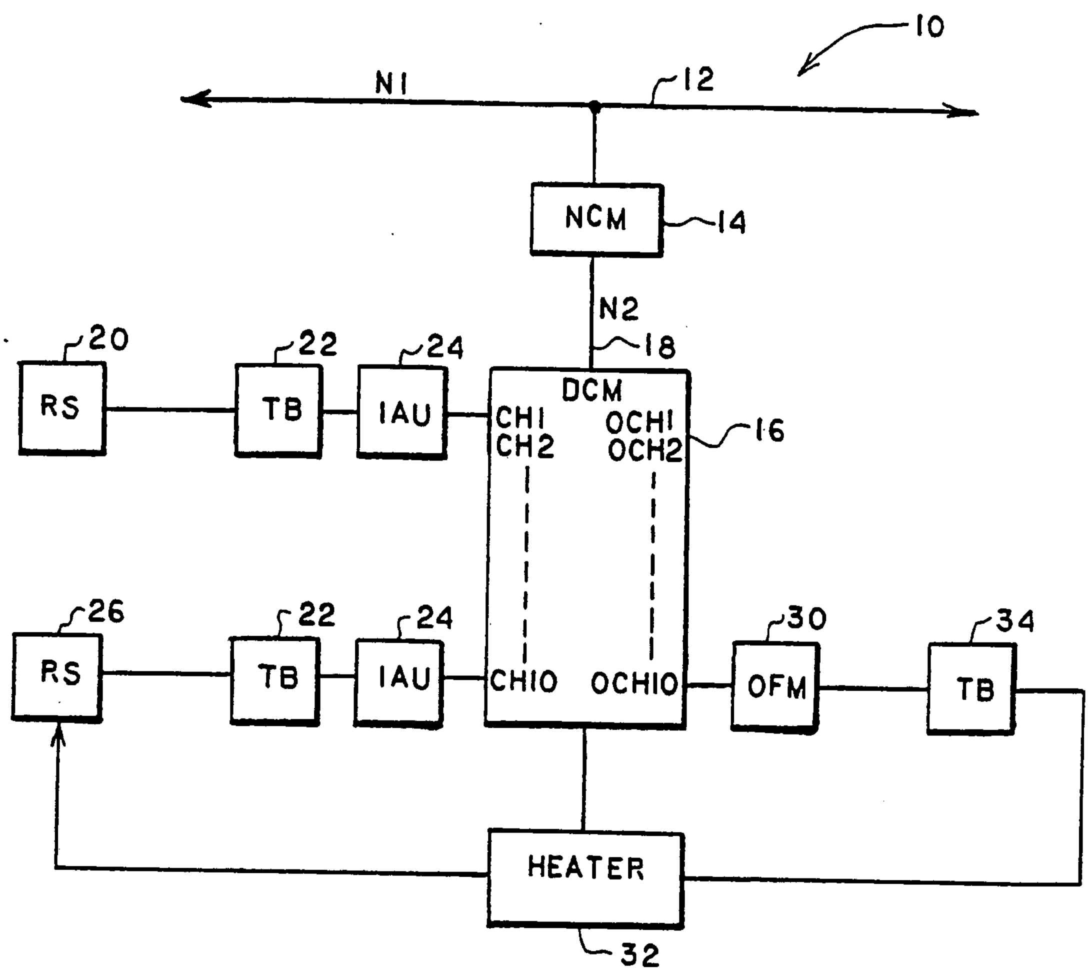
8. A control system input as defined in Claim 7 wherein said circuit select means (70, 90) are selectively operable for applying power to said remote sensor providing said voltage magnitude.

9. A control system input as defined in Claim 5 wherein one of said different types of analog input information is a current magnitude and wherein said circuit select

means (70, 90) are selectively operable for converting said current magnitude to a differential voltage.

10. A control system input as defined in Claim 9 further including resistance means (25) and wherein said circuit select means (70, 90) are selectively operable for placing said resistance means (25) across said differential amplifier inputs (56, 58) and directing said current magnitude through said resistance means (25) to provide said differential voltage.

1/5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N2
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20
RS
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CH2
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CH10
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OFM
34
TB
HEATER
32

FIG. 1

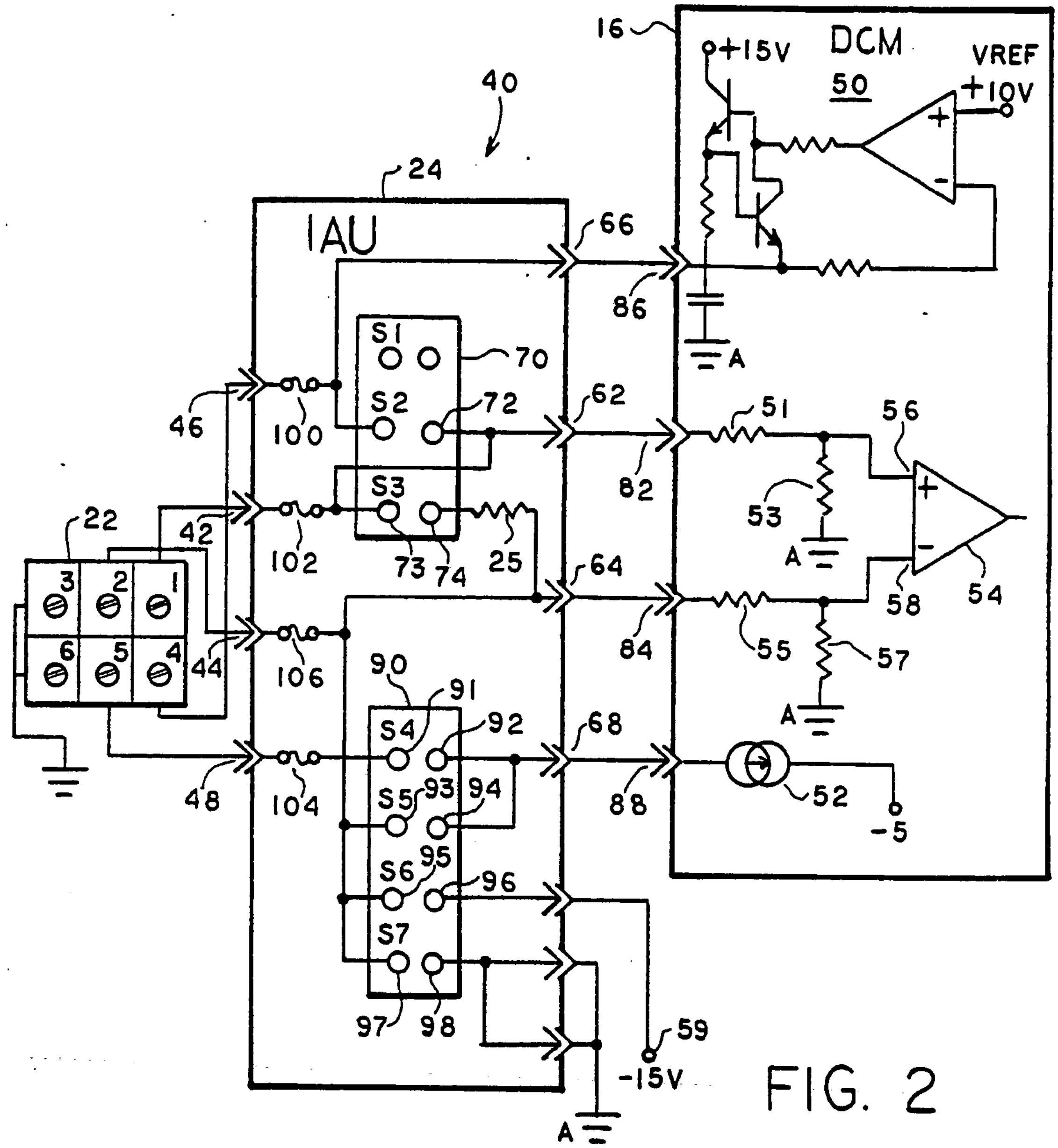


FIG. 2

INPUT APPLICATIONS	JUMPER POSITION		SCREW TERMINALS USED 1	2	4	5
2-WIRE RTD	S2	S5	⊘	⊘		
4-WIRE RTD	S1	S4	⊘	⊘	⊘	⊘
VOLTAGE	S1	S7	⊘	⊘	⊘	
POTENTIOMETER	S1	S7	⊘	⊘	⊘	
3-WIRE XDUCER	S1	S8	⊘	⊘	⊘	
TRUE 2-WIRE CURRENT LOOP	S3	S8	⊘		⊘	
REMOTE CURRENT LOOP	S3	S4	⊘	⊘		

FIG. 3

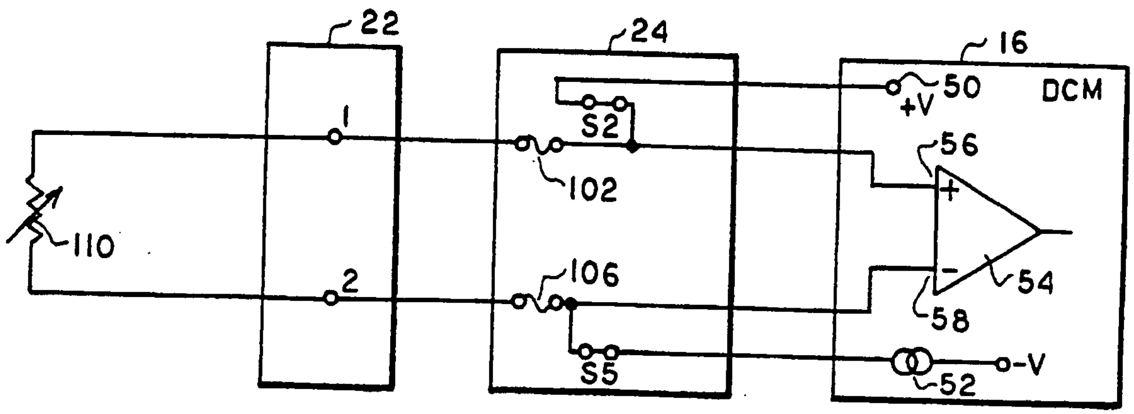


FIG. 4

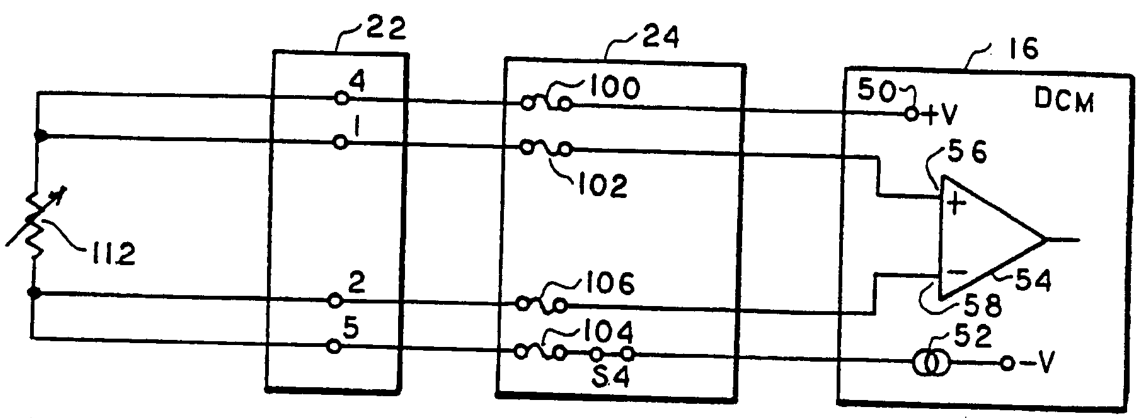


FIG. 5

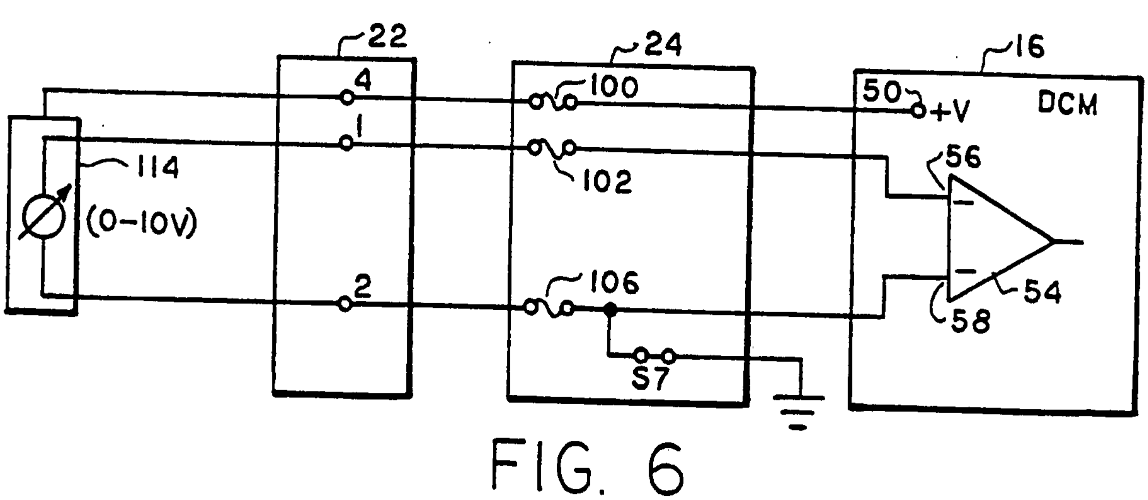


FIG. 6

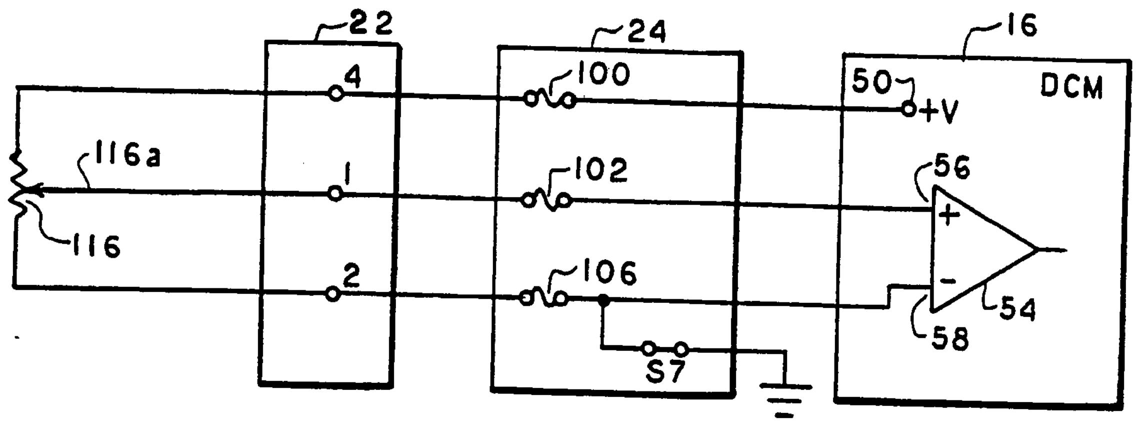

22
24
16
4
100
50
+V
DCM
116a
1
102
56
+
116
2
106
-
54
58
S7

FIG. 7

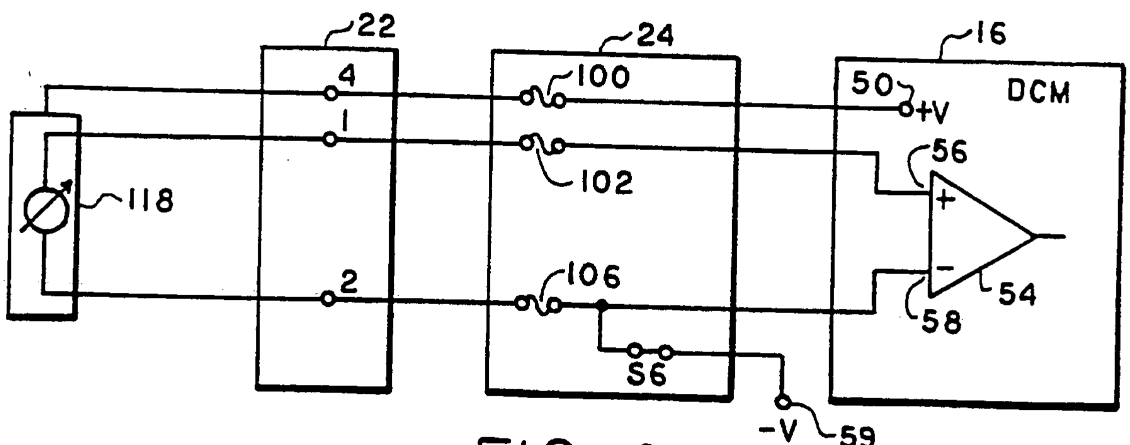
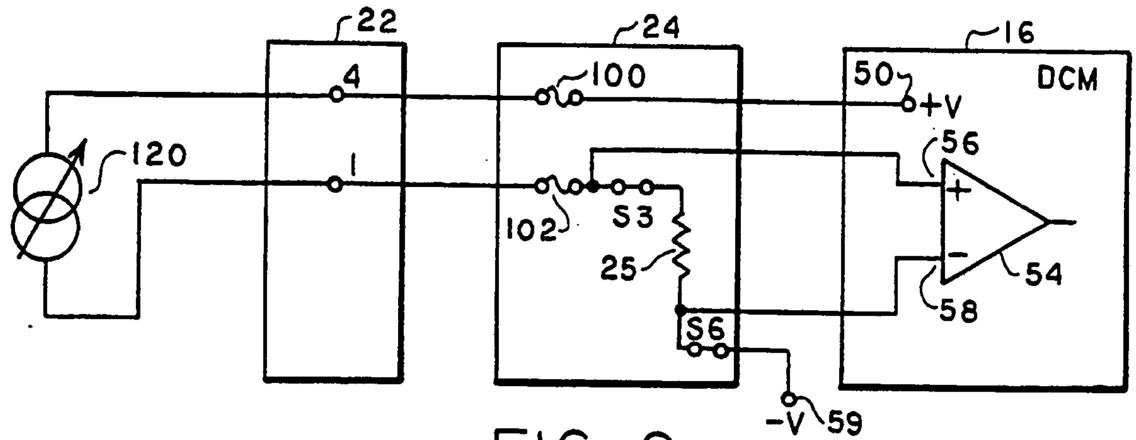

22
24
16
4
100
50
+V
DCM
1
56
102
118
+
2
106
-
54
58
S6
-V
59

FIG. 8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24
16
4
100
50
+V
DCM
120
1
56
+
102
S3
25
-
54
58
S6
-V
59

FIG. 9

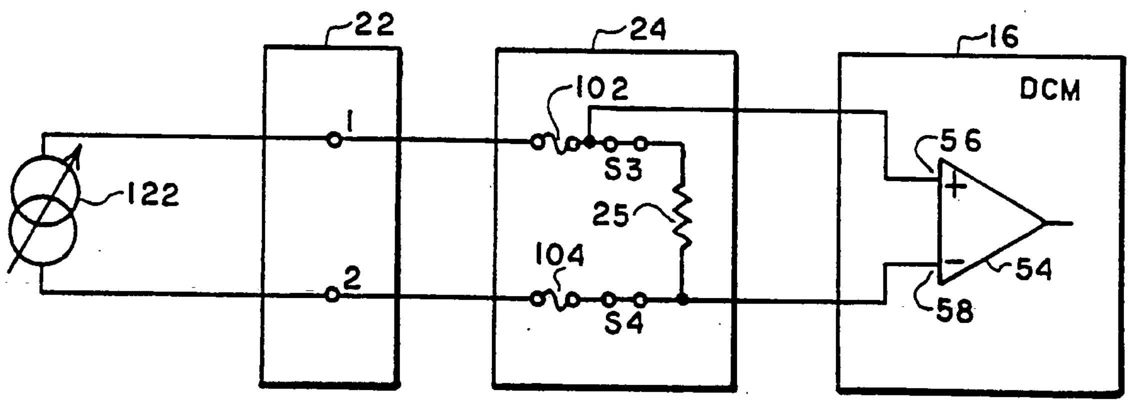
22
24
16
102
DCM
1
56
S3
+
122
25
104
-
54
2
S4
58

FIG.10

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 90/03875

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G05B19/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G05B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	EP,A,301736 (DISTIBUTED MATIX CONTROLS INC.) 01 February 1989 see page 3, line 37 - page 7, line 40; figures 1-7 ---	1-5

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
05 OCTOBER 1990	30. 10. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	RESSENAAR J.P.

1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/US90/03075

SA 38755

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 05/10/90
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-301736	01-02-89	JP-A- 1131999	24-05-89

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82